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March 27, 2007

Mr. Steven Winnett
United Stated Environmental Protection Agency Region I
Mail Code CWQ
One Congress Street
Boston, MA 02114-02023

Subject: Deliverable for Task 2b for New Hampshire TMDL Project; EPA-SMP-07-002

Dear Mr. Winnett,

ENSR is pleased to forward to the United States Environmental Protection Agency (USEPA) Region 1 the second deliverable for **the New Hampshire Total Maximum Daily Load (TMDL) Development** project (EPA –SMP-07-002). This deliverable completes the requirements of Task 2b "Determine ANC Targets" as part of Task 2 Development of Acid Pond TMDLs. We are submitting the following (two hardcopies and electronic submittal) information: (1) this narrative letter and (2) Table 1 "*Mean Daily Minimum pH and Mean Gran ANC Values for Acid Impaired Lakes, 1996-2007*"; and (3) two figures – Figure 1 "Mean of Daily Minimum pH vs Mean ANC for Acid Impaired Lakes, 1996-2007" and Figure 2 "Mean of Daily Minimum pH vs Mean ANC for Acid Impaired Lakes (Where ANC<10), 1996-2007".

As part of its contract with USEPA, Region 1, ENSR is compiling and synthesizing the watershed and water chemistry data required for development of TMDLs for 266 acid-impaired waterbodies in New Hampshire. The complete suite of 266 waterbodies identified for the Acid TMDL study consist of 150 lakes, 2 impoundments, and 114 associated beaches. At the request of NHDES, six additional waterbodies and two more beaches were added to this set (e-mail from Margaret Foss, NHDES; dated March 13, 2007) Table 1 provides a list of the cumulative 158 lakes and impoundments, listed according to their associated Assessment Unit (AU) codes.

As directed by the New Hampshire Department of Environmental Services (NHDES), ENSR will use the Steady State Water Chemistry (SSWC) model developed by Henrikson and Posch (2001) to calculate critical loads and develop TMDLs. This method of determining critical loads is based on water chemistry, annual surface runoff, and specified target Acid Neutralizing Capacity (ANC) as previously developed by the State of New Hampshire (e.g., NHDES, 2004) for acid TMDLs for 86 ponds and as approved by the USEPA.. The following information is provided to detail the sources of data and the process used in Task 2b to further evaluate the target ANC proposed for use in the SSWC model for the 158 waterbodies in the study.

Water quality data (pH and Gran ANC) were obtained by ENSR from the NHDES OneStop Data Retrieval Site (http://www.des.state.nh.us/OneStop.htm). Specifically, data were obtained by querying the Environmental Monitoring Database for grab samples. Queries encompassed the time period of 01/01/1996 through 01/01/2008 (the default end date in the database query page). Outputs from the

database were formatted as Microsoft Excel files and were then placed in a Microsoft Access database, constructed by ENSR. The database was then used to manipulate the data and produce reports.

Data were available for 157 of the 158 lakes. No pH or Gran ANC data were available for Horseshoe Pond (NHLAK700030403-05) for the time period of interest. There were approximately 7,023 pH data points from 276 sampling stations and 2,828 Gran ANC data points from 195 sampling stations. The majority of samples were collected in the summer (June, July, and August).

The mean pH values were calculated for each lake using the minimum value observed on each sampling date across stations and depths. Once minimum daily pH values were obtained, means were calculated by:

- Converting from pH units to hydronium concentration;
- Taking the mean of the minimum daily hydronium concentrations for each lake;
- Converting back to pH units.

The operational procedure used to calculate the means in Access was:

- Take the inverse log (base 10) of the pH value in pH units;
- Take the mean of the reciprocal of the inverse log values;
- Calculate the reciprocal of the means;
- Calculate the base 10 log to convert back to pH units.

A mean Gran ANC value was calculated for each lake using all data obtained from the NHDES database for the specified time period. The mean pH and Gran ANC values are presented in Table 1.

Figure 1 presents a simple linear regression of mean pH vs. mean Gran ANC. Based on the linear regression and using the NH criterion pH of 6.5, the corresponding target ANC value would be **7.64** mg/L (153 ueq/L) with a $R^2 = 0.38$. For comparison, the data were also fitted with a polynomial regression line, which produced a better fit (i.e., $R^2 = 0.50$).

To eliminate the influence of what appeared to be several outliers of ANC data, the same regression was conducted without ANC values greater than 10 mg/L (2000 ueq/L). Figure 2 presents a simple linear regression of mean pH vs. mean Gran ANC values for ANC values less than 10 mg/L. This provides a better fit to the data. Based on the linear regression and a NH criterion pH of 6.5, the corresponding target ANC value would be **6.24** mg/L (125 ueq/L) with a $R^2 = 0.52$. As before, a polynomial curve fit the data slightly better ($R^2 = 0.57$).

We note that these target ANC values are more than twice that reported in the previous TMDL for 65 Acid Impaired New Hampshire Ponds report (NHDES, 2004) – a value of 3.0 mg/L (60 ueq/L). We do not have a ready explanation for these differences in target ANC values, but based on several analyses we do not think the differences are due to the methods used in calculation of the pH values.

We can speculate that there may be ecoregional differences in lake water chemistry between the 2004 TMDL waterbodies and this particular set of 158 ponds due to local geology and/or land use. The lakes in the current data set are found predominantly in the central to southern part of New Hampshire. We do not have information regarding the distribution of the ponds in the 2004 paper.

Comparison of the respective figures from the 2004 paper and this data set indicates that the latter shows a much more rapid increase in ANC with increasing pH; particularly for those ponds with pH values greater than 6.0 (NHDES, 2004). There seems to be a reasonable linear relationship between pH and ANC in the range from 5.0 to 6.0 s.u., but the slope increases sharply in the 6.0 to 6.5 range. Further investigation of this relationship may be warranted to investigate why these two data sets behave differently.

Based on the present data set, the predicted target ANC value at pH 6.5 is **6.24** mg/L (125 ueq/L). This value will be input into the SSWC model as a means of identifying ponds which are not in compliance with NHDES standards.

Please do not hesitate to contact ENSR with any questions regarding the attached table and figures or further clarification on our methods for preparation of these data.

Sincerely yours,

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Project files

Figure 1
Mean of Daily Minimum pH vs Mean ANC for Acid Impaired Lakes, 1996-2007

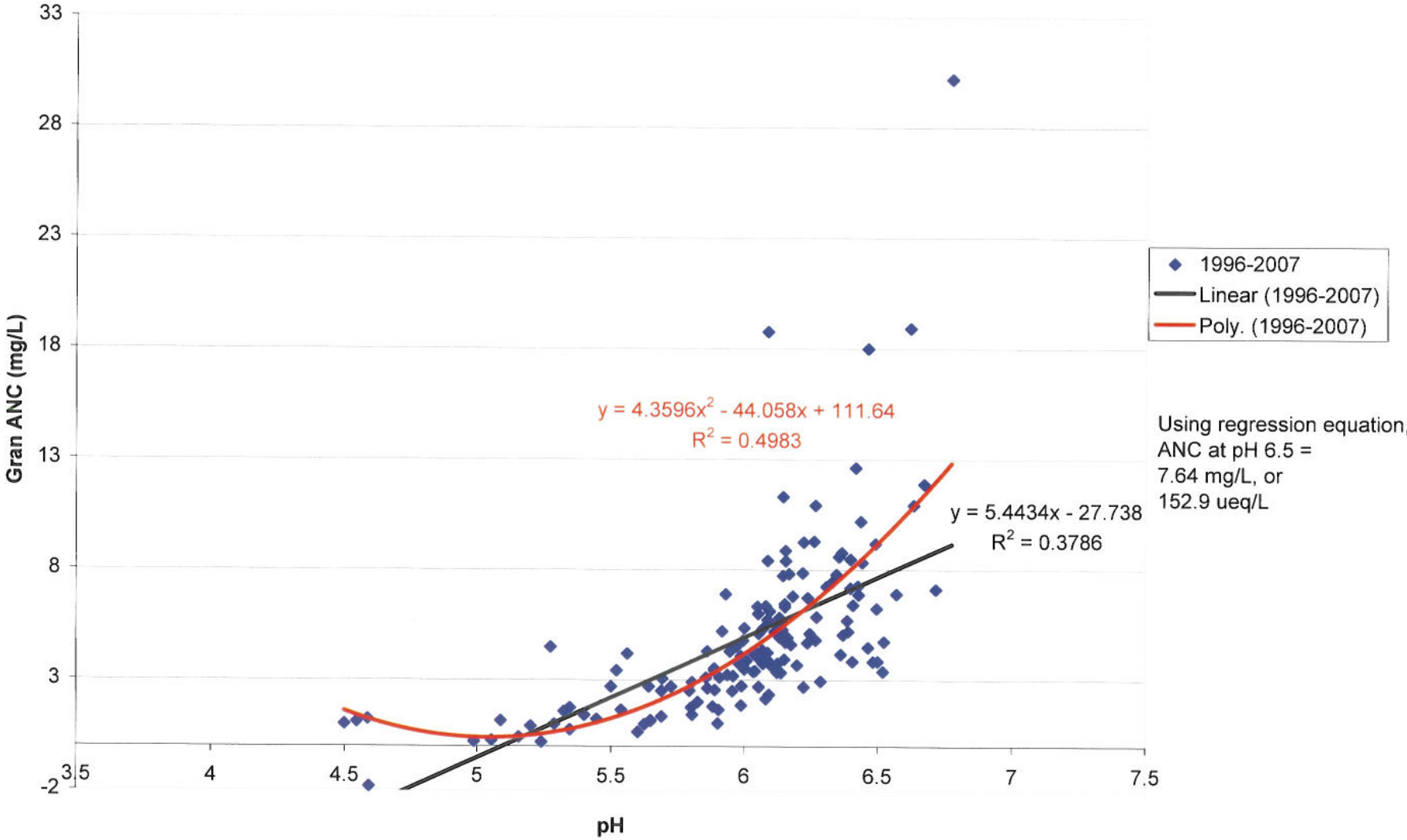
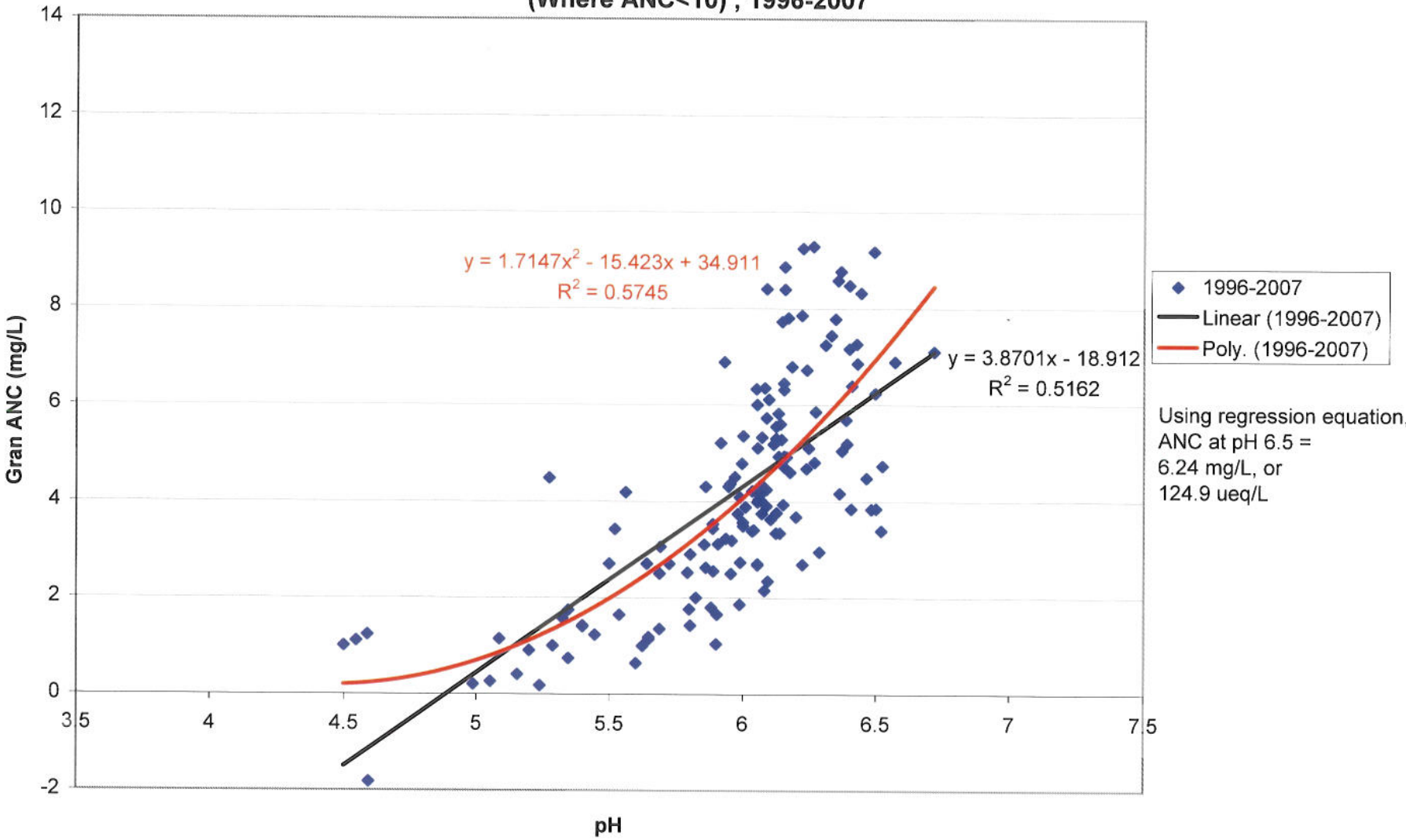


Figure 2
Mean of Daily Minimum pH vs Mean ANC for Acid Impaired Lakes (Where ANC<10) , 1996-2007



Using regression equation, ANC at pH 6.5 = 6.24 mg/L, or 124.9 ueq/L